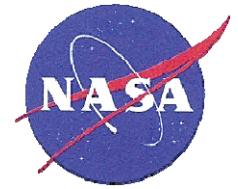


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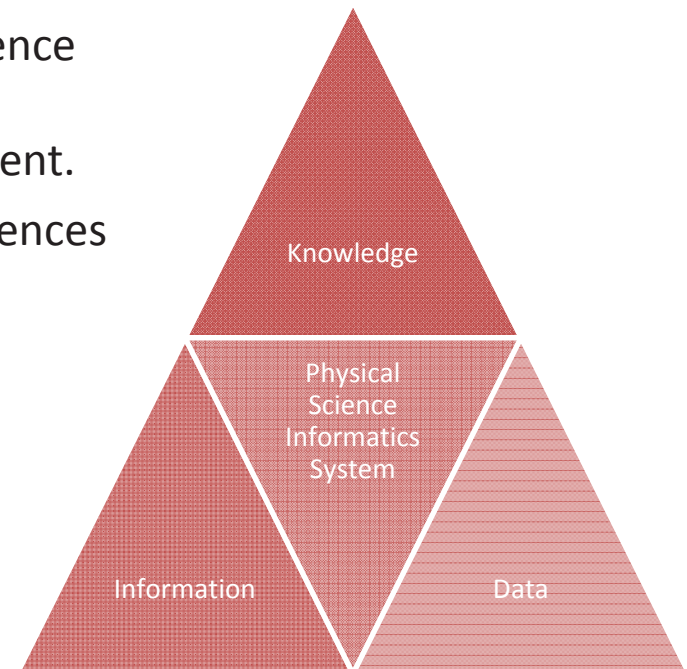
# Physical Science Informatics: Providing Open Science Access to Microheater Array Boiling Experiment Data

John McQuillen  
Robert D. Green  
Ben Henrie  
Teresa Miller  
Fran Chiaramonte

# Objective



- Physical Science Informatics system implements Office of Science and Technology Policy (OSTP) memorandum, Feb. 22, 2013 entitled “Increasing Access to the Results of Federally Funded Scientific Research” by enabling multiple researchers simultaneous, **open-science**, access to synergistically build upon ISS data.
- Maximize the value of this important data by mass disseminating past, current, and future ISS physical science data to the broad science, engineering, and STEM community including industry, academia, and government.
- Accelerate from ideas to state-of-the-art of physical sciences research and to products, publications, and patents.



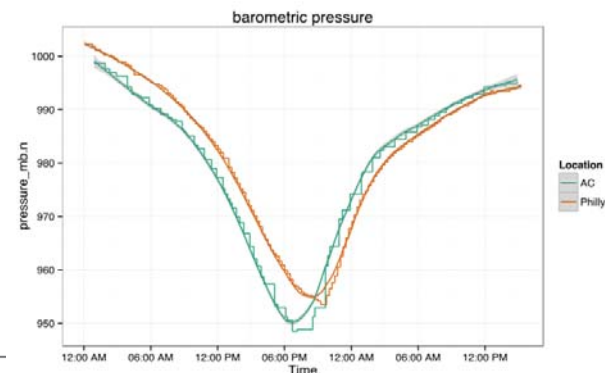
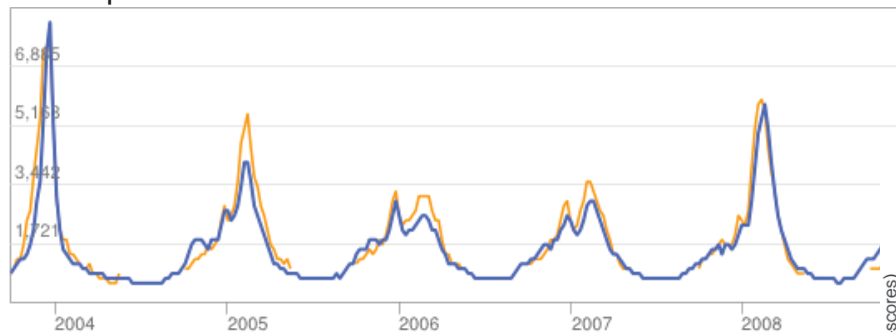
# Open Science Examples



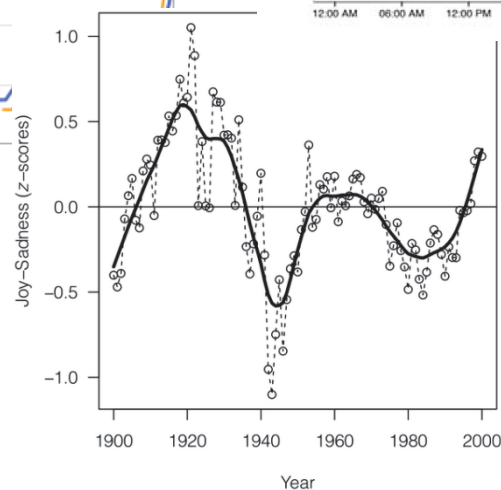
- Data science: A new emerging field with the goal of “extracting meaning from data and creating data products”. [definition courtesy of Wikipedia.]
- Has emerged as a new field to glean knowledge and new understanding from the large volume and diversity of data being published or available and accessible on the internet.

- Examples:

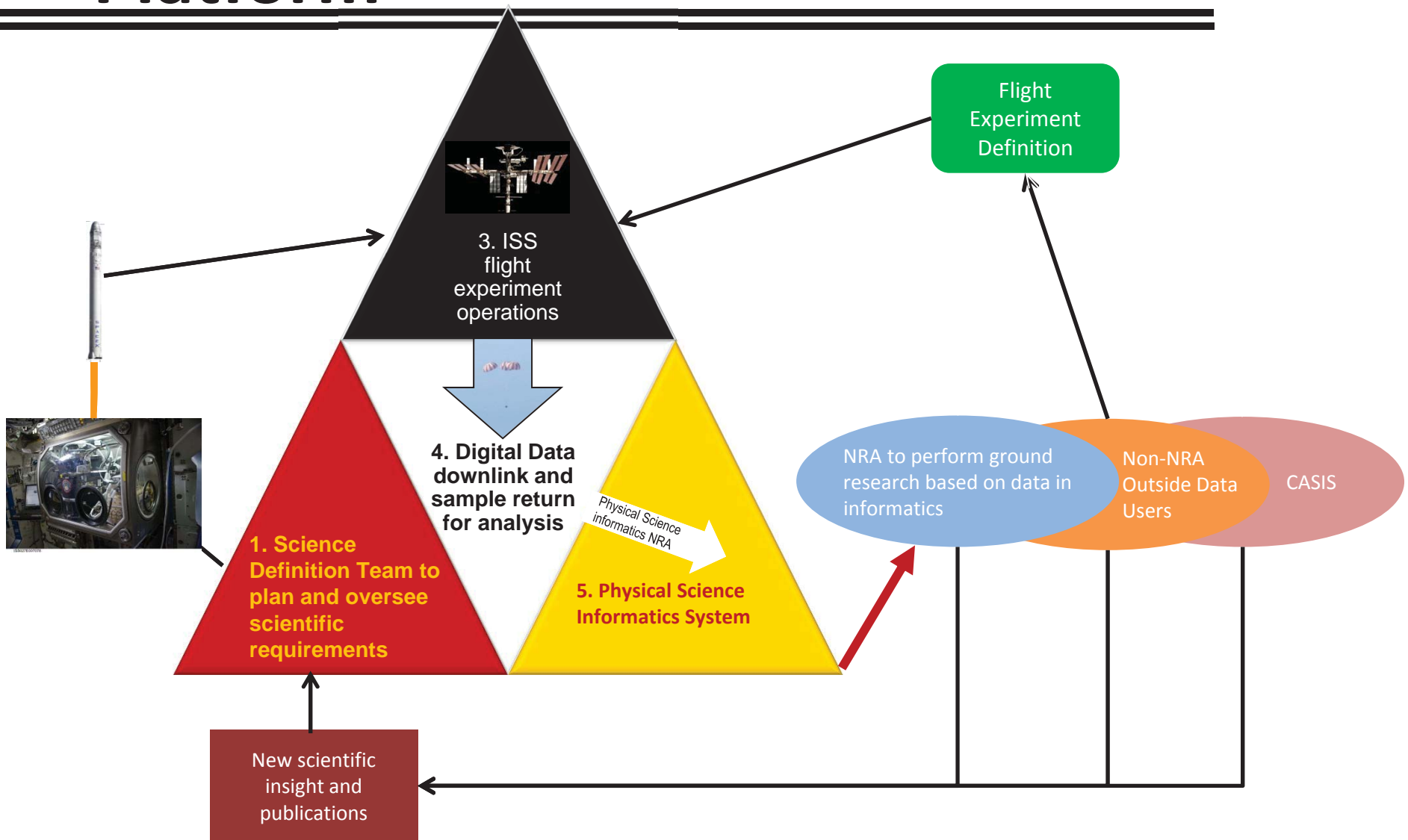
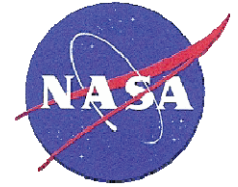
- Tracking Hurricane Sandy: Barometric pressure data from local weather stations, available on-line, accurately track the storm's path.



- Google researchers discovered close relationship between searches on flu-related topics and spread of influenza. Published in Nature Vol 457, 19 February 2009, doi:10.1038/nature07634
- Human behavior researchers using Google n-gram database (data from Project Gutenberg) found evidence for distinct historical periods of positive and negative moods in 20<sup>th</sup> century books.



# Open Science Campaign Platform\*



22 Sept 2014

\*Marshall Porterfield – based on the ISS Science Campaign White Paper 2013



# BXF Overview

The Boiling eXperiment Facility was installed in the Microgravity Science Glovebox (MSG):

- Two distinct experiments:
  - Micro-heater Array Boiling Experiment (MABE) PI: Prof. Jungho Kim, University of Maryland
  - Nucleate Pool Boiling Experiment (NPBX) PI: Prof. Vijay K. Dhir, University of California at Los Angeles
- *Normal*-perfluorohexane,  $C_6F_{14}$ , as the test fluid
- Operated between pressures of 60 to 244 kPa and temperatures of 35 to 60 °C.
- Measured Pressure and bulk fluid temperature.
- Acquired standard rate video.

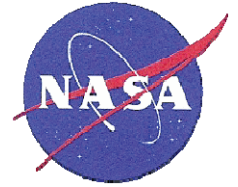
## Timeline

- BXF was delivered to the ISS aboard ULF-5, which launched in February, 2011.
- BXF was installed on Tuesday March, 22.
- Week 1: Hardware setup and checkout, MABE and NPBX heater characterizations
- Weeks 2 and Week 3: MABE and NPBX test points .
- On Monday, April 11, anomalous pressure readings tripped the BXF safety circuit, halting operations. Attempts to restart/reset/recycle BXF did not correct these readings and BXF was shut down.
- By this point MABE completed 260 of 540 tests. NPBX completed less than half of planned tests.
- On-orbit troubleshooting was performed via ground-control.
- Limited NPBX operations could still be performed without failed power bus.
- BXF was removed from MSG and returned on ULF-7.



ESA Astronaut Paulo Nespoli installing BXF in MSG

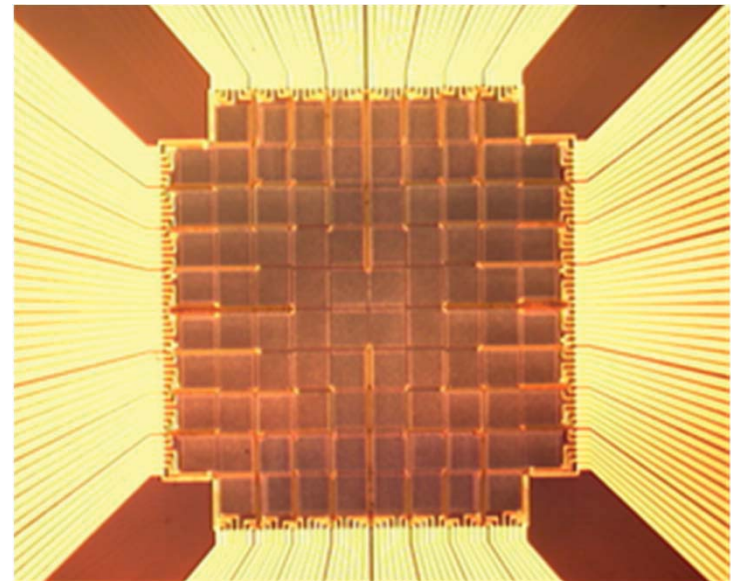
# Microheater Array Boiling Experiment (MABE)



Determined the local boiling heat transfer mechanisms in microgravity for nucleate and transition boiling and the critical heat flux by examining the position of the liquid and vapor adjacent to the heater.

MABE was incorporated two 96-element microheater arrays, to measure localized heat fluxes while operating at a constant temperature.

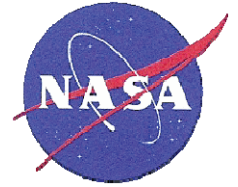
- 2.7 by 2.7 mm (not acquired)
- 7.0 by 7.0 mm





# Physical Science Informatics Platform

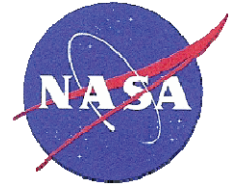
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- **Accessibility** - Available to the national and international user community, using popular devices such as iPhone, iPad, Android, PC, Mac, Linux with web-based Google like search capability
- **Collaboration** - Allow for data to data links, and provide researchers the ability to comment about the data in either private or public discussions
- **Generate metric and usage reports** - Track usage for NASA managers and the science definition teams in planning, gap analysis, data ranking, student (undergraduate and graduate) impact, and for future system improvement.
- **Security and Access Controls** - Access controls will protect the data according to the data agreement and to support security controls for SBU, International Traffic in Arms Regulations (ITAR), company proprietary, or Export Administration Regulations (EAR), data system will need to be on a NASA moderate security plan
- **Export tools** are available to through a set of web services so that a variety of research tools can be used to analyze the data.

# Requesting Access

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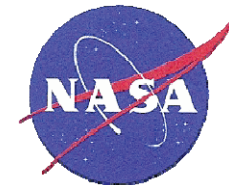
**Website access requires a USERID and Login.**

Submit form at <http://psi.nasa.gov/Request.aspx>:

- First, Middle and Last Name
- Phone
- Email
- Organization
- Address
- City
- Country
- State
- Postal Code
- Citizenship
- Company
- Manager's Information
  - First and Last Name
  - Phone
  - Email
- Projects (NASA tracks who uses the database and what they use it for. Ultimately, this is one metric used to warrant continuation of this resource)
- Justification



# PSI Introduction Page



URL <http://psi.nasa.gov>

Advanced Search

ISS Physical Science Informatics System

BROWSE BY -

Facilities

Investigations

Investigator Names

home

help

## Welcome to ISS Physical Science Informatics System

**Overview:**

NASA's Physical Sciences Research Program, along with its predecessors, has conducted significant fundamental and applied research, which has led to improved space systems and produced new products offering benefits on Earth. NASA's experiments in the various disciplines of physical science, reveal how physical systems respond to the near absence of gravity. They also reveal how other forces that on Earth are small compared to gravity, can dominate system behavior in space. The International Space Station (ISS) is an orbiting laboratory that provides an ideal facility to conduct long-duration experiments in the near absence of gravity and allows continuous and interactive research similar to Earth-based laboratories. This enables scientists to pursue innovations and discoveries not currently achievable by other means. NASA's Physical Sciences Research Program also benefits from collaborations with several of the ISS international partners—Europe, Russia, Japan, and Canada—and foreign governments with space programs, such as France, Germany and Italy. The scale of this research enterprise promises new possibilities in the physical sciences, some of which are already being realized both in the form of innovations for space exploration and in new ways to improve the quality of life on Earth.

**Research Areas:**

**Biophysics:** biological macromolecules, biofluids, biomaterials, and biological physics

**Combustion Science:** spacecraft fire safety, droplets, gaseous - premixed and non-premixed, solid fuels, and supercritical reacting fluids

**Complex Fluids:** colloids, liquid crystals, foams, non-newtonian fluids, and granular flows

**Fluid Physics:** two-phase flow, phase separation, boiling, condensation and capillary and interfacial phenomena

**Fundamental Physics:** space optical/atomic clocks, quantum test of equivalence principle, cold atom physics, critical point phenomena, and dusty plasmas

**Materials Science:** crystal growth, metal and alloys, electronic materials, glasses and ceramics, and polymers

**Implementing Centers:**

NASA's Physical Sciences Research Program is carried out at the Glenn Research Center (GRC), Jet Propulsion Laboratory (JPL) and Marshall Space Flight Center (MSFC).

**Heritage:**

Space Life and Physical Sciences Division 2012 - present  
ISS Research Project 2006-2012  
Advanced Life Support - Life Support and Habitation Program 2004-2006  
Office of Biological and Physical Research Program 1998-2004  
Microgravity Research Program 1984-1998

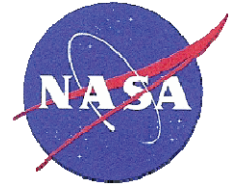
A photograph of the International Space Station (ISS) in orbit above Earth. The station's complex structure, including multiple modules and large solar panel arrays, is clearly visible against the blue and white background of the planet.

NASA Official: Teresa Miller

MSFC Safety Reporting System  
Privacy and Legal Statements

Curator: Julia M Reynolds  
Powered by the Athena Platform

# Investigations Page

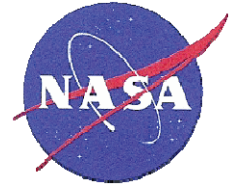


General Search, searches all records and attached files

The screenshot shows the PSI Physical Science Informatics System (PSI) website. The top navigation bar includes the NASA logo, a search bar, and the text "Welcome to ISS Physical Science Informatics System (PSI)". Below the navigation bar are tabs for Facilities, Investigations, Publications, Reports, Research Area, and Researchers, along with an "Add Record" button. The main content area displays a "SEARCH RESULTS" window with a table of investigations. The table has columns for checkboxes, investigation names, and the word "Investigations". The "Microheater Array Heater Boiling Experiment (MABE)" row is selected, indicated by a red checkmark in the checkbox column.

choose category:	All	starts with:	All	Select All	Generate Report
<input type="checkbox"/>	Capillary Channel Flow (CCF)		Investigations		
<input type="checkbox"/>	Capillary Flow Experiment (CFE)		Investigations		
<input type="checkbox"/>	Capillary Flow Experiment-2 (CFE-2)		Investigations		
<input type="checkbox"/>	Constrained Vapor Bubble (CVB)		Investigations		
<input type="checkbox"/>	Constrained Vapor Bubble-2 (CVB-2)		Investigations		
<input type="checkbox"/>	DECLIC, Directional Solidification Experiment (DSI)		Investigations		
<input type="checkbox"/>	DEvice for the study of Critical Liquids and Crystallization - High Temperature Insert-Reflight (DECLIC HTI-R or SCWM/HTI-R)		Investigations		
<input checked="" type="checkbox"/>	Microheater Array Heater Boiling Experiment (MABE)		Investigations		
<input type="checkbox"/>	Nucleate Pool Boiling Experiment (NPBX)		Investigations		

# Experiment Record



Microheater Array Heater Boiling Experiment (MABE)

Edit Record Download Record Generate PDF Share

Was this information helpful?  0  0

Notify Me ☐

home help

General Investigat... Scientific... Engineerin... Resulting ... Comments (0)

General

Investigation Name: MABE

Investigation Title: Microheater Array Boiling Experiment

Research Area: Fluid Physics

Sponsoring Space Agency: National Aeronautics and Space Administration (NASA)

Investigation Performed On: International Space Station

Principal Investigator(s): Kim, Junggho

Co-Investigator/Collaborator(s): McQuillen, John B.

Inside NASA Firewall Only to edit/update/add new records

Export reports to excel or PDF

Generate reports to compare data or identify data gaps

# Investigation Overview Tab



Microheater Array Heater Boiling Experiment (MABE)

Edit RecordDownload RecordGenerate PDFShare

Was this information helpful?

0

0

Notify Me

GeneralInvestigat...Scientific...Engineerin...Resulting ...Comments (0)

Investigation Overview

Research Objectives:

Boiling efficiently removes large amounts of heat by generating vapor from liquid; this process is currently being used in many power plants to generate electricity. An upper limit, called the critical heat flux, exists where the heater is covered with so much vapor that liquid supply to the heater begins to decrease, potentially destroying the heater. Microheater Array Boiling Experiment (MABE) d ...

Show More+

Research Overview:

Microheater Array Boiling Experiment (MABE) is one of two investigations scheduled to operate in the Boiling eXperiment Facility (BXF). The other investigation is Nucleate Pool Boiling Experiment (NPBX).

Space Applications:

Understanding of microgravity effects on boiling mechanisms is critical to the proper design of heat removal equipment for use in space-based applications. In microgravity, a bubble can cover an entire heater array instead of just a small area, resulting in burnout of components if local hot spots are present. The increased spatial resolution of these measurements will enable the extent of the dry spot to be measured along with the heat transfer from the liquid surrounding the dry spot. This technique can be applied to other areas including spray coo ...

Show More+

Earth Applications:

The proposed research has shown that transient conduction is the dominant heat transfer mechanism in boiling of refrigerants-like fluids. This research will provide insight into creating more efficient cooling systems on Earth.

Other Information:

MABE Other Information

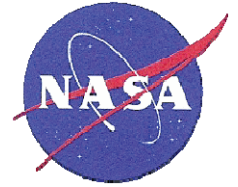
22 September 2014

ITTW 2014

12



# Scientific Data and Information



Microheater Array Heater Boiling Experiment (MABE)

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General Investigat... Scientific... Engineerin... Resulting ... Comments (0)

Scientific Data and Information

Experiment Data: [MABE Test Runs](#)

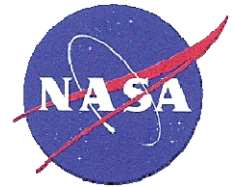
Science Requirements Document(s): [SRD\\_04032.pdf](#)

Where the Video and Data will be Stored

Experiment Definition

22 September 2014

# Engineering Data And Information



Microheater Array Heater Boiling Experiment (MABE)

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Was this information helpful? 0 0

Notify Me ☐

General Investigat... Scientific... Engineerin... Resulting ... Comments (0)

Engineering Data and Information

Engineering Drawings & Documents: Displaying 16 files.

- M01A2071\_TEST CHAMBER ASSEMBLY.pdf
- M01A2131\_TEST CHAMBER TOP PLATE ASSEMBLY.pdf
- M01A2151\_COOLING CHAMBER ASSEMBLY.pdf
- M01A2161\_MABE HEATER BONDING ASSEMBLY.pdf
- M01A2161\_MABE HEATER BONDING ASSEMBLY.pdf
- M01A2161\_MABE HEATER BONDING ASSEMBLY.pdf
- M01A2161\_MABE HEATER BONDING ASSEMBLY.pdf
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- M01A2161\_MABE HEATER BONDING ASSEMBLY.pdf
- M01A2161\_MABE HEATER BONDING ASSEMBLY.pdf

Increment(s): [Increment 25/26](#) [Increment 27/28](#)

Facilities: [Microgravity Science Glovebox \(MSG\)](#)

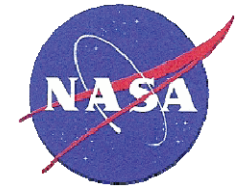
Selected Drawings & Engineering Reports and Test Data Relevant to Analysis of Scientific Data.

Other Experiments Operating during Same time frame.

ISS Facility Used

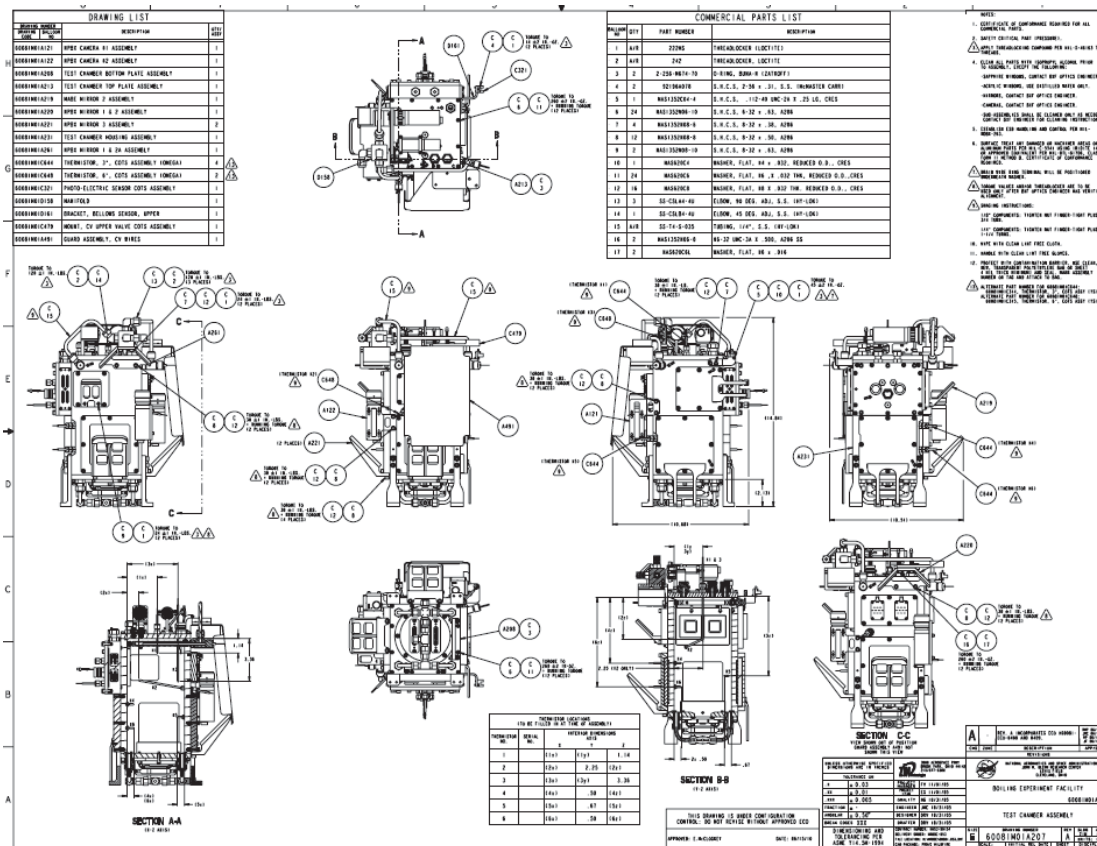


# Engineering Data

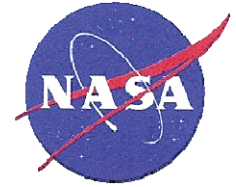


## Note:

- Units are typically in SAE (inches, pounds, etc.)
- BXF had several hundred drawings, analyses, reports, etc.
- Only those files that are needed for interpretation of science data (for example position of sensors) have been entered.
- Other files can be requested.
- Some files will not be entered; for example, drawings related to hardening of high-speed camera because of proprietary nature.

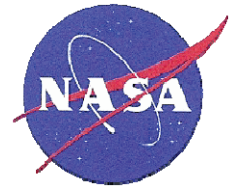


# Current Engineering Data Online



Drawing No.	Title	Rationale
60081M01A207	TEST CHAMBER ASSEMBLY	Overall Assembly
60081M01A213	TEST CHAMBER TOP PLATE ASSEMBLY	Position of Pressure Sensor Taps
60081M01A215	COOLING CHAMBER ASSEMBLY	Positioning of Heater Arrays and Backside Cooling
60081M01A216	MABE HEATER BONDING ASSEMBLY	Positioning of Heater Arrays
60081M01C311	CARTRIDGE HEATER, COTS ASSEMBLY	Bulk Fluid Heater
60081M01C314	THERMISTER, 3", COTS ASSEMBLY	Bulk Fluid Temperature Sensor
60081M01C315	THERMISTER, 6", COTS ASSEMBLY	Bulk Fluid Temperature Sensor
60081M01D110	HOUSING, TEST CHAMBER	Test Chamber
60081M01D169	HOUSING, COOLING CHAMBER	Backside Cooling Chamber
60081M01D171	PLATE, TEST CHAMBER TOP	Top of Test Chamber
60081M01D172	DUCT, MIXING, TEST CHAMBER, STRAIGHT	Annular Tube for Bulk Fluid Heater
60081M01D173	DUCT, MIXING, TEST CHAMBER, ANGLE	Annular Tube for Bulk Fluid Heater
60081M01L267	BXF/MSG LAYOUT	All Components
60081M01S291	BXF FLUIDS SCHEMATIC FLIGHT SYSTEM	Fluid System Schematic
	BXF Critical Design Review Charts	

# Publications and Other Results



Microheater Array Heater Boiling Experiment (MABE)

Boiling Experiment Facility for Heat Transfer Studies in Microgravity. 46th AIAA Aerospace Sciences Meeting and Exhibit. January 2008

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Was this information helpful?  0  0

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General Related In... Comments (0)

General

**Title:** Boiling Experiment Facility for Heat Transfer Studies in Microgravity

**Author(s):** R DeLombard, JB McQuillen, D Chao

**Reference:** R DeLombard, JB McQuillen, D Chao. "Boiling Experiment Facility for Heat Transfer Studies in Microgravity". 46th AIAA Aerospace Sciences Meeting and Exhibit. January 2008

**Abstract:** Image Only

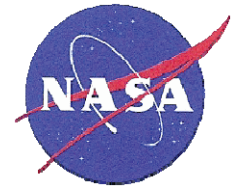
**Detailed Author Information:** [McQuillen, John B.](#)

**Publication Year:** 2008

**Link to Publication:** [Boiling Experiment Facility for Heat Transfer Studies in Microgravity](#)

Some reports are on-line and publicly available, However, others may require a subscription to the appropriate journal .

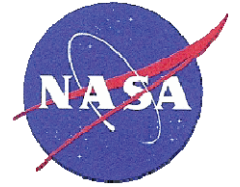
# Plans



- **PSI Database becomes publicly available during October 2014.**
- **Limited Data for MABE is on-line.**
  - **Drawings**
  - **Reports**
  - **Links to publications**
  - **“Raw” Excel Spreadsheets for MABE Test Cases**
  - **Downlinked Video**
- **Data to be posted:**
  - **Processed Local Heat Transfer Coefficient**
  - **Synchronized Video Data (Side View and Through Array)**

# Comments, Suggestions

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MABE Specific:

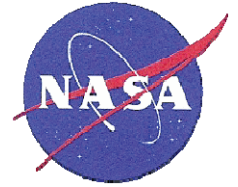
Types of Data to see

Format of Data

PSI Database

Presentation Format

# Comments, Suggestions



- Who to contact:
  - MABE: [John.B.McQuillen@nasa.gov](mailto:John.B.McQuillen@nasa.gov)
  - Informatics Science: [Robert.D.Green@nasa.gov](mailto:Robert.D.Green@nasa.gov)
  - Database: [Ben.Henrie@nasa.gov](mailto:Ben.Henrie@nasa.gov)

A screenshot of a web browser window displaying the "Microheater Array Heater Boiling Experiment (MABE)" interface. The window has an orange title bar. Below the title bar, there are four buttons: "Edit Record", "Download Record", "Generate PDF", and "Share". To the right of these buttons, there is a section for user feedback with the text "Was this information helpful?" and two thumbs-up/down icons, both showing a count of 0. Below this is a "Notify Me" checkbox. The main content area has a tabbed interface with tabs for "General", "Investigat...", "Scientific...", "Engineerin...", "Resulting ...", and "Comments (0)". The "Comments (0)" tab is selected. Under the "Comments" heading, there is a text input field labeled "My Comment:". Below the input field is a "Post" button. To the right of the "Post" button is another "Notify Me" checkbox.